

Sediment and Radiocesium Runoff after Fukushima Accident

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Radionuclides were released by the accident at the Fukushima Daiichi Nuclear Power Plant, and radiocesium, ^{137}Cs and ^{134}Cs , were deposited on the soil surface. All of the residents within 50 km of the plant were forced to move. Five years after the accident, residents still have not returned because decontamination efforts that remove topsoil around houses, agricultural lands, and forests requires a lot of time. Focusing on the forests, it is impossible to remove all of the topsoil, and thus estimates of radiocesium movements are needed. Radiocesium is adsorbed on soil and organic matter (IAEA, 2010). Their movements would be equivalent to soil particle movements, through soil erosion and sediment transport. In this study, field monitoring was conducted to estimate radiocesium runoff from two comparative watersheds, and the WEPP model was applied to simulate soil and radiocesium erosion and transport.

The study sites were two watersheds in Iitate Village, Fukushima, Japan (Figure 1). The southern observation watershed (Hiso River watershed, 25.6 km²) has higher radiation levels compared to the northern Mano River watershed (10.8 km²). Forest accounts for close to 75% of the land area in both watersheds. Sediments containing radiocesium carried by runoff from surrounding lands into the rivers were monitored. A monitoring system is composed of a rain gauge, water level sensor, water velocimeter, turbidity sensor, and water sampler (Figure 2).

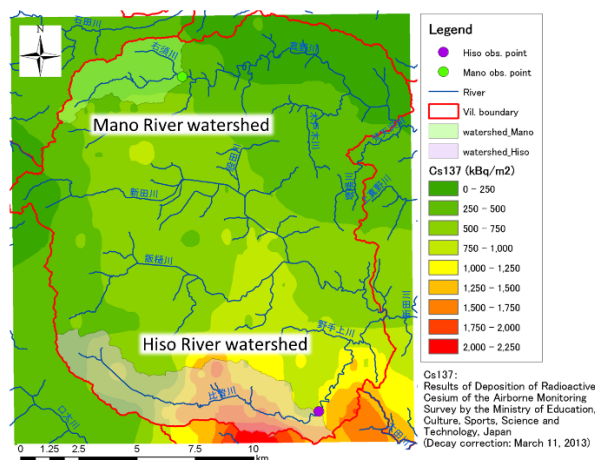


Figure 1. Cs-137 levels in Iitate Village.

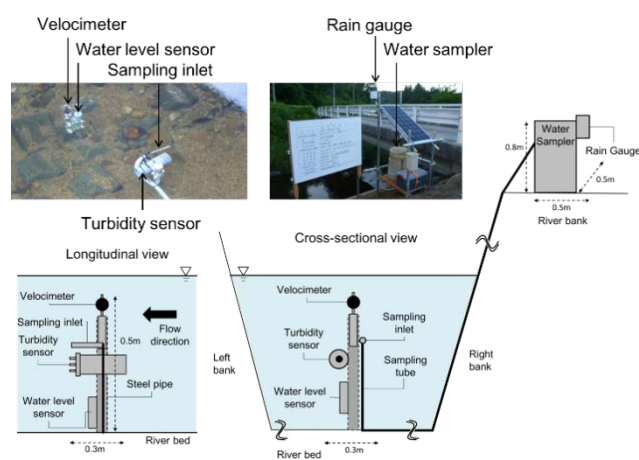


Figure 2. Instruments for field monitoring.

Correlations between suspended sediment concentrations (SSC) with ^{137}Cs concentrations in storm waters are shown in Figure 3, and were approximately linear. This means radiocesium was discharged with the suspended sediment and organic matter. Comparing the two watersheds, the slope of the regression line at Hiso was greater than that at Mano, which means radiocesium content in the suspended sediment at Hiso was larger than that at Mano. This also agrees with the distribution of radiocesium content in the topsoil shown in Figure 1. Focusing on sediment particle size, more than 80% of the radiocesium was adsorbed on finer particles such as clay, silt, and fine sand as shown in Figure 4. Monitored total amounts are summarized in Table

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1. Hiso radiocesium losses were greater than those at Mano even though sediment yield was smaller, and this was due to the greater concentrations of radiocesium at Hiso. Spatially averaged ^{137}Cs contents at Hiso and Mano were 1017 kBq/m^2 and 421 kBq/m^2 . Thus, decontamination of radiocesium in topsoil by natural soil erosion processes may not be effective.

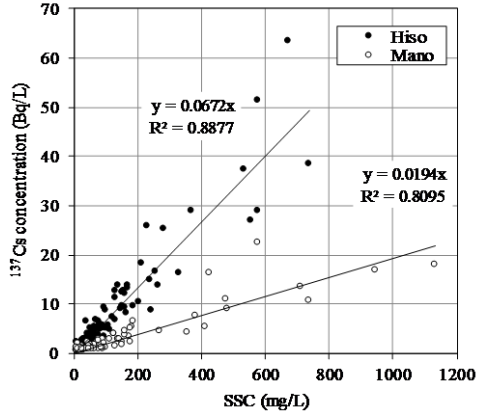


Figure 3. Relationships of SSC with ^{137}Cs concentration in the storm water.

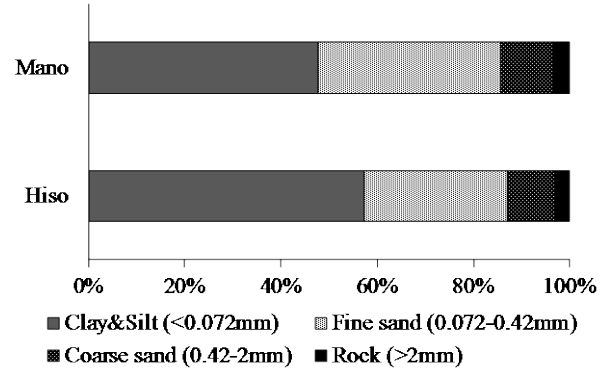


Figure 4. Ratios of each particle size in ^{137}Cs content in suspended sediment.

Table 1. Monitored and calculated total amounts from June 2013 to December 2014.

Site	Precipitation (mm)	Water runoff (mm)	Sediment yield (g/m^2)	^{137}Cs runoff (Bq/m^2)	^{134}Cs runoff (Bq/m^2)
Mano (Obs.)	849	534	33.0	671	282
Hiso (Obs.)	974	529	18.5	1278	437
Mano (WEPP)	849	116	26.2	900*	-
Hiso (WEPP)	974	102	12.3	1980*	-

*Annual value (January 2013 to December 2014)

Datasets for the WEPP model were prepared to estimate the sediment and radiocesium movements in these watersheds. Here, WEPP v2012.8 and GeoWEPP for ArcGIS 9.X were used. To estimate radiocesium runoff, the radiocesium deposition map (Figure 1) was used. In this study, we assumed radiocesium was uniformly distributed within the 0-5 cm soil layer. Results are shown in Table 1 and Figure 5, and were reasonable. In the future, some management practices that minimize the radiation dose will be investigated.

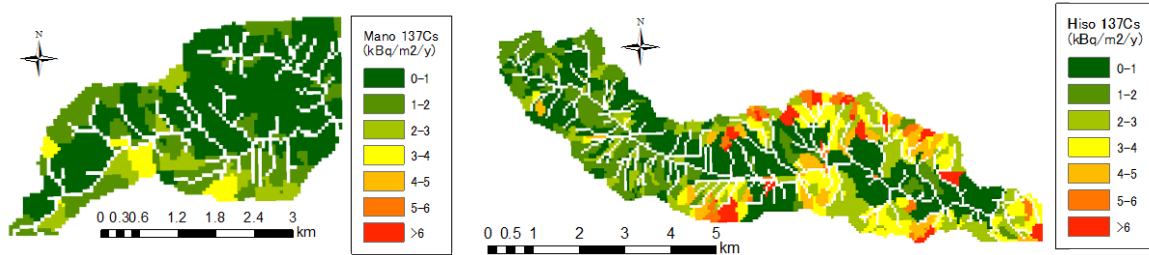


Figure 5. Calculated ^{137}Cs yield distribution by WEPP model. Left: Mano, Right: Hiso.

References

IAEA. 2010. Handbook of parameter values for the prediction of radionuclide transfer in terrestrial and freshwater environments. International Atomic Energy Agency, Technical Report Series No. 472.